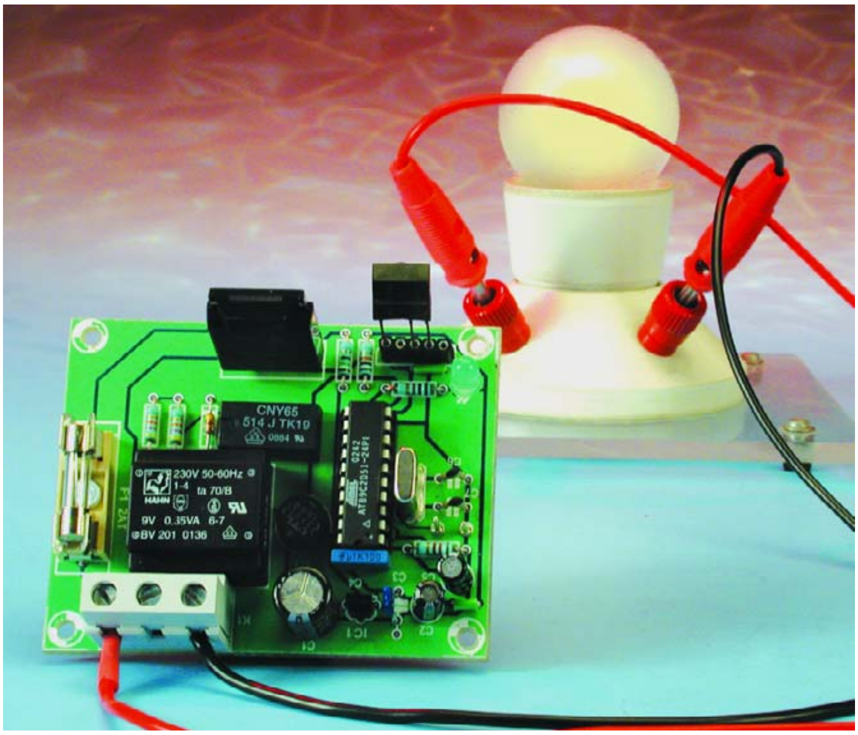
Remote Light Control with Dimmer

Responds to RC5 infrared commands

Design by A. Oyrer

The microcontroller-driven switch described in this article allows one lamp to switched on and off as well as dimmed, all using an RC5-compatible infrared remote control.

There is a great deal of lavishness in being able to switch a lamp on and off without getting out of your chair, and even more in brightness control from the same comfortable position! A small microcontroller circuit makes it all possible. As a bonus, the circuit provides a soft start / soft turn off function, which means that the lamp is switched on and off gradually rather than abruptly.



Zero crossing

Like nearly all dimmer circuits, the project described here relies on phase angle control of the alternating voltage applied to the lamp. The process not only improves the life expectancy of the lamp, but also prevents (within limits) unnecessary electromagnetic 'pollution' in the direct vicinity of the dimmer and/or the lamp. To be able to dim a lamp using phase angle control, it is necessary for the circuit to detect when the instantaneous level of the mains voltage equals zero volts. **Figure 1** illustrates how the microcontroller is able to detect this instant called 'zero-crossing'. The mains voltage is applied to the LED inside an optocoupler. Resistance R1+R2 limits the current through the LED (during the positive half cycle of the mains voltage) as well as through D1, which quasi shunts the negative half wave across the LED. Only the positive half waves will arrive at the microcontroller input, the negative halves are missing. To prevent the microcontroller from firing the triac every second half wave only (which would cause the lamp to flicker), a software trick is used to ensure the triac is fired a second time, with a delay, during the second half wave.

It would have been possible to 'tap' the zero-crossings from the secondary of the mains transformer by connecting a diode between the rectifier and the smoothing capacitor. Arguably, the 100-Hz signal at this point appears useful. However, we would easily run into problems with the phase shift caused by the transformer, hence the first solution (direct detection of the mains voltage) is preferred.

Not so long ago, the functionality and performance expected from a dimmer like the one described here could only be realized using esoteric, purpose-designed integrated circuits. Today, a job is done by a low-cost common or garden microcontroller like the AT89C2051 with a minimum of hardware around it: a power-on reset (POR) network, a zero-crossing detector (described above), a 5-volt power supply using a miniature transformer, an infrared detector/decoder on connector K2, an on/off switch, a status LED (which lights when the lamp is off) and, finally, a triac which governs the voltage applied to the lamp.

Triac IC4 contains a TLL-compatible input that can be controlled from a microcontroller output with just one series resistor inserted in the drive line. The circuit has been designed with electrical isolation and safety in mind. When fitted with a heatsink, the S202S11 is capable of supplying lamp currents of up to 8 A. Note, however, that fuse F1 protects the copper tracks on the board by melting if the load (lamp) current exceeds 2 A.

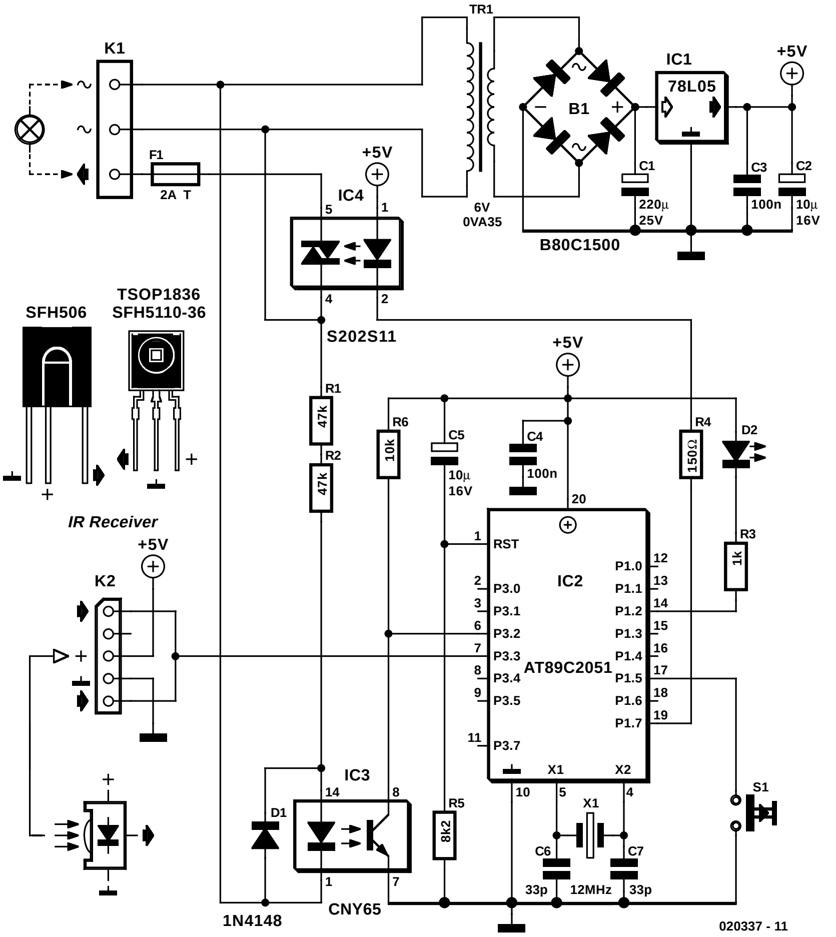


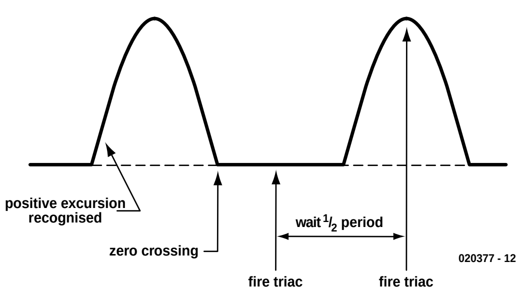
Figure 1. A dimmer circuit based on a microcontroller means that there are very few parts indeed.

Other switches

The dimmer has three remote controlled functions. The lamp is switched on and off (also possible using S1) by pressing the Sound A/B pushbutton; Vol+ to raise lamp brightness and Vol– to dim it. These default pushbutton functions may be changed (by reprogramming) to suit your requirements. To get into programming mode, keep S1 pressed for about 2 seconds **when the lamp is off**. The lamp will come on briefly. The microcontroller now waits for a signal from your RC5 compatible IR remote control, and the pushbutton you press will act as the on/off

Software operation

Whenever the software is not busy processing a received RC5 code, it is constantly measuring the period duration of the mains voltage. The measured value is divided by two to enable the software to 'know' when the triac is to be fired (triggered) during the missing half wave. The zero crossing detector employs an external interrupt (EX0Interrupt) triggered by a falling edge at pin P3.2 (pin 6) of the controller. When such an interrupt is signalled, Timer 1 is started. When an overflow occurs, a Timer1Interrupt is generated which leads to the triac being fired. Next, Timer1 is set to the previously measured value of the half period length and then restarted. After 10 ms (at 50 Hz) the second fire pulse occurs. In this way, the phase angle control takes place every half cycle of the mains voltage.



The timer inside the 89C2051 operates as a counter clocked at a frequency equal to fosc/12 (here, 1 MHz). The counter register is incremented at the seconds rate. An overflow of the 12-bit timer causes an interrupt.

The Reload value is calculated in the Timer1 interrupt routine. Besides, a bit is available that toggles at each Timer overflow:

Bit = 0: Timer being loaded for shifted triac firing instant;

Bit = 1: Timer being loaded with 10 ms (at 50 Hz) for triac firing during negative half wave.

The Reload value for Timer1 may be decreased or increased by pressing the remote control keys.

When the lamp is switched on or off the Reload value is changed cyclically. This automated process can not be affected using the remote control. If you want a different behaviour, other increments, or other intervals then you'll need to edit the software using the source code file. You will also need a suitable assembler and a programmer.

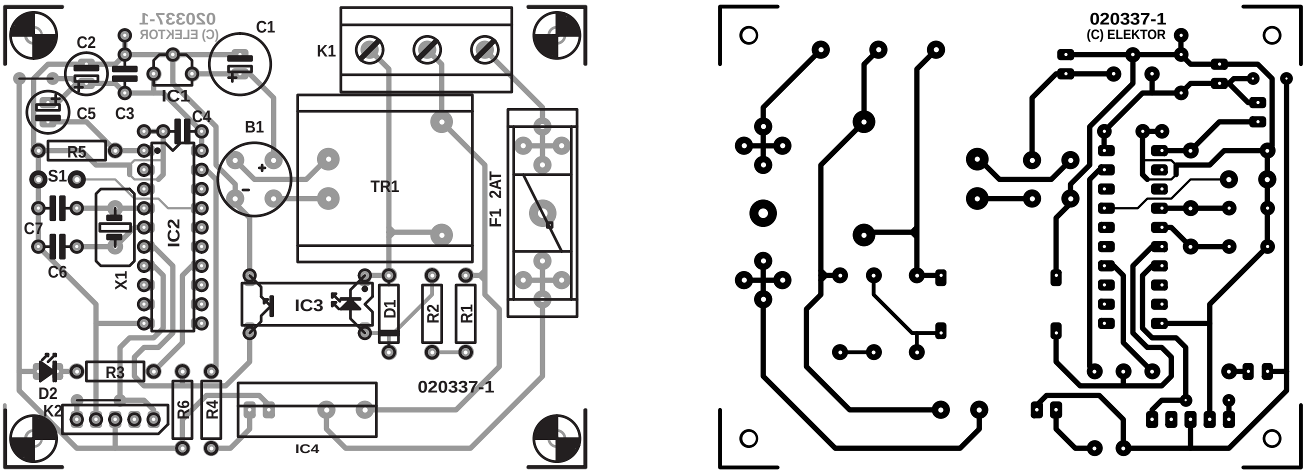


Figure 2. Copper track layout and component mounting plan of the PCB designed for the remote controlled dimmer (board available from The PCBShop).

control in the future. Press S1 again, and the lamp will light up twice. Now program the pushbutton for the 'raise brightness' control. A third press on S1 (three flashes from the lamp) and you can program the pushbutton you want to use for 'lower brightness'. After successful programming of the new pushbutton functions, the lamp will come on.

When the remote control is switched on or off with S1, the lamp is not switched on and off abruptly. Rather, it comes on gradually (within approx. 1.5 s) and is slowly quenched (within approx. 3 s). The switch-on period was purposely shortened to ensure the room is quickly lighted. When the lamp is switched on by means of the remote control the brightness is not maximum but the last adjusted value.

Printed circuit board

The layout of the printed circuit board shown in **Figure 2** is generous because there was no need to make the circuit as compact as possible. None the less, the dimensions of the board should allow the circuit to be built into a surface pattress, a dry line box or a switch and socket box.

The construction should start with the mounting of the two wire links beside C2/C5 and K2. Next, the components may be fitted in the usual order: from small to large. **Do not attempt to replace R1 and R2 by a single resistor**, because its voltage rating would be insufficient. The microcontroller should be mounted in a socket, if only to be able to reprogram the device.

It should be noted that the circuit board is connected to the **lethal** mains voltage, hence an approved enclosure with protective earthing must be used, and every precaution taken that no parts can be touched when the circuit is in operation. If you need to work on the circuit when it is being powered, always use a safety transformer. The fuse on the board should be covered with a cap to eliminate the risk of an erring test probe or, worse, a finger touching the mains voltage.

Finally, a few words on the infrared receiver module. Several types currently available on the market may be used without problems, as long as they are specified for a frequency of 36kHz. Unfortunately, there is no such thing as pin compatibility in this area, so if necessary consult the datasheets before connecting your module to the circuit via K2. Starting at pin 1, the pin functions are:

Signal; not used; +5 V, Ground; Signal.

which should allow various IR receiver/detector modules to be connected without too much bending of connecting wires. The optics of the module should be the only parts that protrude from the housing in which the circuit is built.

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Free Downloads

Microcontroller software (Hex and source code files).
File number: **030337-11.zip**
PCB layout in PDF format.
File number: **020337-1.zip**
www.elektor-electronics.co.uk/dl/dl.htm, select month of publication.

COMPONENTS LIST

Resistors:
R1,R2 = 47kΩ
R3 = 1kΩ
R4 = 150Ω
R5 = 8kΩ2
R6 = 10kΩ

Capacitors:
C1 = 220µF 25V radial
C2,C5 = 10µF 16V radial
C3,C4 = 100nF
C6,C7 = 33pF

Semiconductors:
B1 = B80C1500 (round case, 80V piv, 1.5A)
D1 = 1N4148
D2 = LED, low current
IC1 = 78L05
IC2 = AT89C2051-12 (order code **020337-41**)
IC3 = CNY65
IC4 = S202S211

Miscellaneous:
K1 = 3-way PCB terminal block, lead pitch 7.5mm
K2 = SFH110-36, TSOP1836 (see text)
S1 = pushbutton, 1 make contact
Tr1 = mains transformer, 6V 0.35VA (e.g., Hahn BV2010106)
X1 = 12MHz quartz crystal
F1 = fuse, 2AT (time lag), with PCB mount holder and cap
Disk, HEX and source code files, order code **020337-11** or Free Download.